A tutorial Guide

for operating Hydroponic system using Solar Energy

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Abstract

Solar cells and solar cell panels are the current devices of the photovoltaic effect, in which the solar energy can be directly converted into electrical energy.

It is clean energy, eco-friendly, reliable and efficient. We have used a panel with the next specifications: Size 1980 cm X 990 cm X 50 mm to produce max Power Voltage 36V DC - Max Power Current 6.94A - 250 watt.

Produced voltage is converted by an inverter to a value of 220v AC to be used to feed water pumps to raise water to the system.

The obtained results showed that to have the best performance of the panel voltage is to keep the other solar component “mppt, battery, inverter and switched” as close as possible to the panel to avoid voltage lost.

Also the panel load must not exceed 3 water pumps that are run on 220v Ac each to be worked with full capacity.

Keywords

Solar energy, Solar panels, clean energy, Solar system, Energy transfer, Electrical load, Hydroponic system, solar power component, solar power installation, Photovoltaic, Arduino, renewable energy.

Chapter (1)

Introduction

- **Project needs**

As we know, we are in urgent needs to find new sources, ways and techniques to reclaim more areas and to develop agriculture to cope with over population needs.

We need a smart, quick, reliable solution to solve this problem, A solution that covers the problems of space needed to grow plants, power supply, continuously observation, make it off grid agricultural system and also can grow different kinds of plants.

- **Solution**

So as a result of that the Hydroponics project came as a solution in which we grow plants without soil “by replacing the dirt and soil with a chemical sol. Has allthe minerals and elements that plant needs which exist in soil” and supply all thepower that the system needs with clean energy from the sun through Solar system.

The solar system’s energy used to provide a water pump with electrical power to left water to the top of the system to pass by plants till come back to where its started “closed cycle”.

To successfully built and construct a Hydroponic system you must have the following elements:

- Solar energy system
- Place to construct
- Prototype for hydroponic “There are 6 basic types of hydroponic systems: Wick, Water Culture, Ebb and Flow (Flood & Drain), Drip (recovery or non-recovery), N.F.T. (Nutrient Film Technique) and Aeroponic”.
- Water supply + nutritional sol.
- Water pumps.
- Tubes, wires, wooden stands.

And the solar system consists of the following components:

- Solar panel
- DC battery 12v
- MPPT
- Inverter 12v to 220v
- Control system
- Switches + wires

Chapter (2)

Solar panel structure

- **Basic principle**

Photovoltaic (PV) systems convert sunlight directly to electricity. They work any time the sun is shining, but more electricity is produced when the sunlight is more intense and strikes the PV modules directly (as when rays of sunlight are perpendicular to the PV modules). Unlike solar thermal systems for heating water, PV does not use the sun's heat to make electricity. Instead, electrons freed by the interaction of sunlight with semiconductor materials in PV cells are captured in an electric current.

Photovoltaic effect, process in which two dissimilar materials in close contact produce an electrical voltage when struck by light or other radiant energy. Light striking crystals such as silicon or germanium, in which electrons are usually not free to move from atom to atom within the crystal, provides the energy needed to free some electrons from their bound condition. Free electrons cross the junction between two dissimilar crystals more easily in one direction than in the other, giving one side of the junction a negative charge and, therefore, a negativevoltage with respect to the other side, just as one electrode of a battery has a negative voltage with respect to the other. The photovoltaic effect can continue to provide voltage and current as long as light continues to fall on the two materials. This current can be used to measure the brightness of the incident lightor as a source of power in an electrical circuit, as in a solar power system.

Solar cell, also called photovoltaic cell, any device that directly converts the energy in light into electrical energy through the photovoltaic effect. The overwhelming majority of solar cells are fabricated from silicon—with increasing efficiency and lowering cost as the materials range from amorphous (noncrystalline) to polycrystalline to crystalline silicon forms.

Unlike batteries or fuel cells, solar cells do not utilize chemical reactions or require fuel to produce electric power, and, unlike electric generators, they do not have any moving parts.

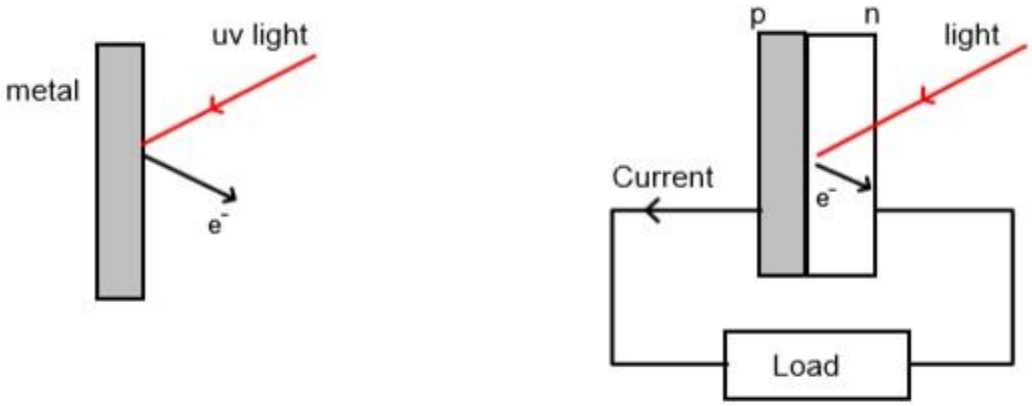

Fig. 2.1 Comparison of the photoelectric effect (left), where uv light liberates electrons from the surface of a metal, with the photovoltaic effect in a solar cell (right). The photovoltaic cell needs to have some spatial asymmetry, such as contacts with different electronic properties, to drive the excited electrons through the external circuit.

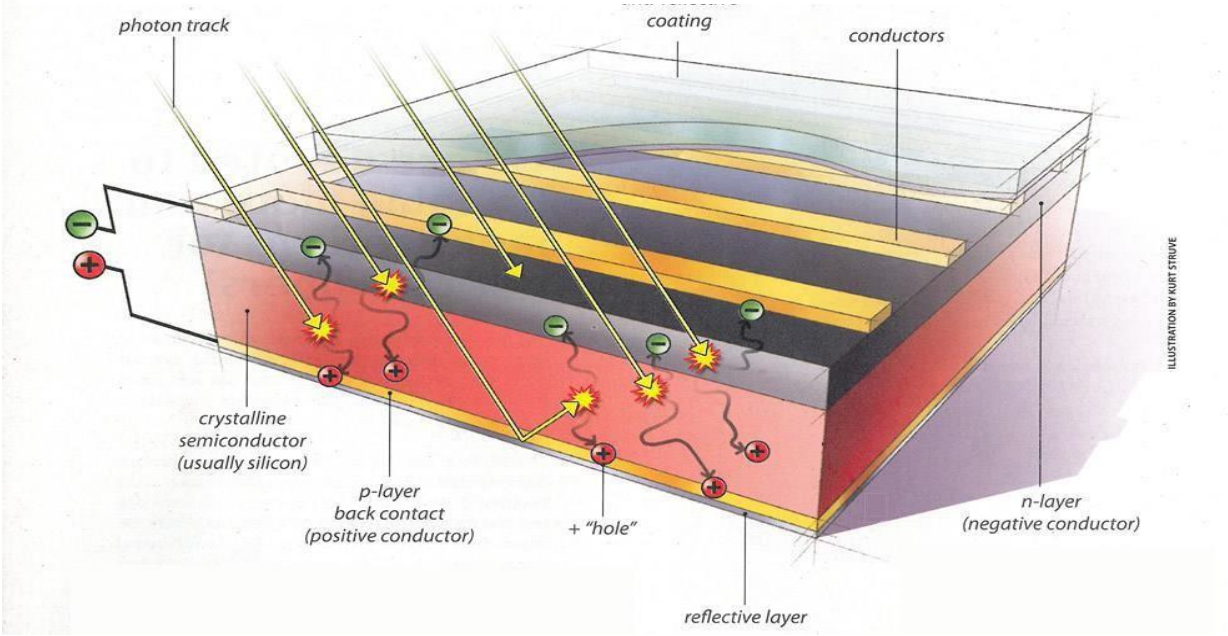

Fig. 2.2 Photons strike and ionize semiconductor material on the solar panel, causingouter electrons to break free of their atomic bonds. Due to the semiconductor structure, the electrons are forced in one direction creating a flow of electrical current. •Solar cells are not 100% efficient in Diagram of a typical crystalline silicon solar cell. Solar cells are not 100% efficient in part because some of the
light spectrum is reflected, some is too weak to create electricity (infrared) and some (ultraviolet) creates heat energy instead of electricity.

- **Cell patterns and photovoltaic array**

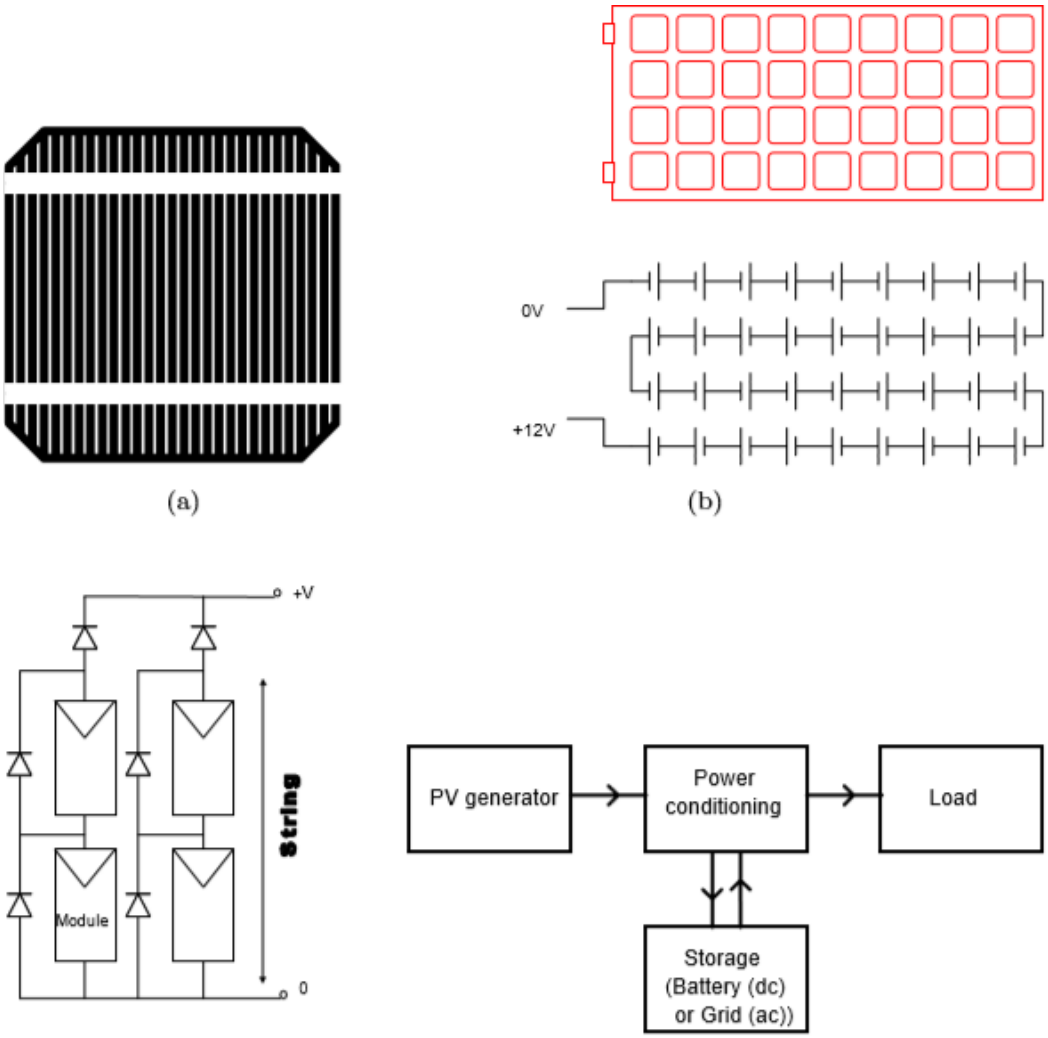

Fig. 2.3 (a) Photovoltaic cell showing surface contact patterns (b) In a module, cells are usually connected in series to give a standard dc voltage of 12 V (c) For any application, modules are connected in series into strings and then in parallel into an array, which produces sufficient current and voltage to meet the demand. (d) In most cases the photovoltaic array should be integrated with components for charge regulation and storage.

Chapter (3)

Solar system component and elements

As we mentioned that the solar system consists of the following components:

- Solar panel
- DC battery 12v
- MPPT or charge controller
- Inverter 12v to 220v
- Control system
- Switches + wires

Now we shall have each of them in detail

Solar panel

- Produces DC voltage and the amount of this voltage is proportional to the size of the panel, as the size of the panel increase the voltage increases.
- The solar panel must be installed by 45 degree angle in the direction of southeast to make the best use of sun rays.
- The most benefit of the solar energy is when the sun rays are perpendicular to the panel's surface.
- Dirt on the panel's surface can slightly reduce efficiency and can be removed by clean dry piece of cloths.
- Size 1980 cm X 990 cm X 50 mm.
- Max Power Voltage 36V - Max Power Current 6.94A - 250 watt solar panel.
- Open Circuit Voltage 44V - Short Circuit Current 7.62A
- Module Efficiency 15.8% 125x125mm cells.
- Tolerance Wattage 0-10W.
- Cables Length -900mm.
- Allowable Hail Load - Steel bar about 3m height.

Fig. 3.1 showing the solar panel and its 45 degree installation

DC Battery 12v

- That is rechargeable battery 12v **“**sealed calcium premium battery”.
- Battery’s job is to make the system working during the night.
- It’s input comes from the mppt or the charge controller.
- The inverter 12v DC input comes from the battery.
- During the day battery charge from the panel and gives the inverter 12v DC at the same time.

Fig. 3.2 (a) the 12v battery

Fig. 3.2 (b) the 12v battery

Fig. 3.2 (c) the 12v battery

MPPT (**M**aximum **P**ower **P**oint **T**racker) or charge controller

- MPPT is an electronic DC to DC converter that optimizes the match between the solar array (PV panels), and the battery bank or utility grid.
- In our case we have a panel that produces about 36v DC and a battery that takes 12v DC , so the mppt reduces the voltage from 36v to 12v.
- the charge controller do the same as the mppt
- It has 1 input and 2 outputs; input for the power comes from the panel, output for the battery and the other for the load if it exists.

Fig. 3.3 the MPPT or charge controller

Inverter

- A solar inverter, or converter or PV inverter, converts the variable direct current (DC) output of a photovoltaic (PV) solar panel into a utility frequency alternating current (AC) that can be fed into a commercial electrical grid or used by a local, off-grid electrical network.
- It is a critical balance of system (BOS)–component in a photovoltaicsystem, allowing the use of ordinary AC-powered equipment.
- Solar power inverters have special functions adapted for use with photovoltaic arrays, including maximum power point tracking and anti-islanding protection.
- In our case the solar power inverters converts 12v DC to 220v AC.

Fig. 3.4 the solar inverter

Control system

- A model of 2 boxes one takes 220v AC coming from the inverter and the other gives 220v + information code powered by Arduino to 4 or more water pumps, to run each pump at a certain time and to organize pumps work.
- “Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online.You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on wiring), and the Arduino Software (IDE), based on Processing”.

Fig. 3.5 (a) The control system

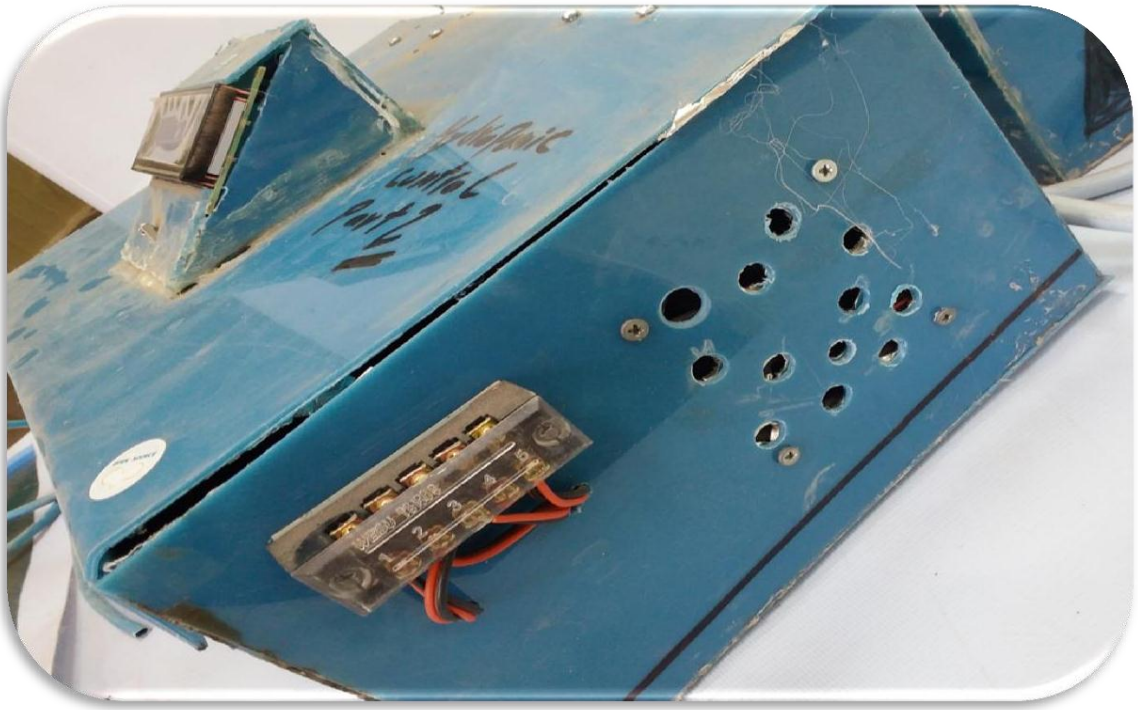

Fig. 3.5 (b) The control system

Fig. 3.5 (c) The control system

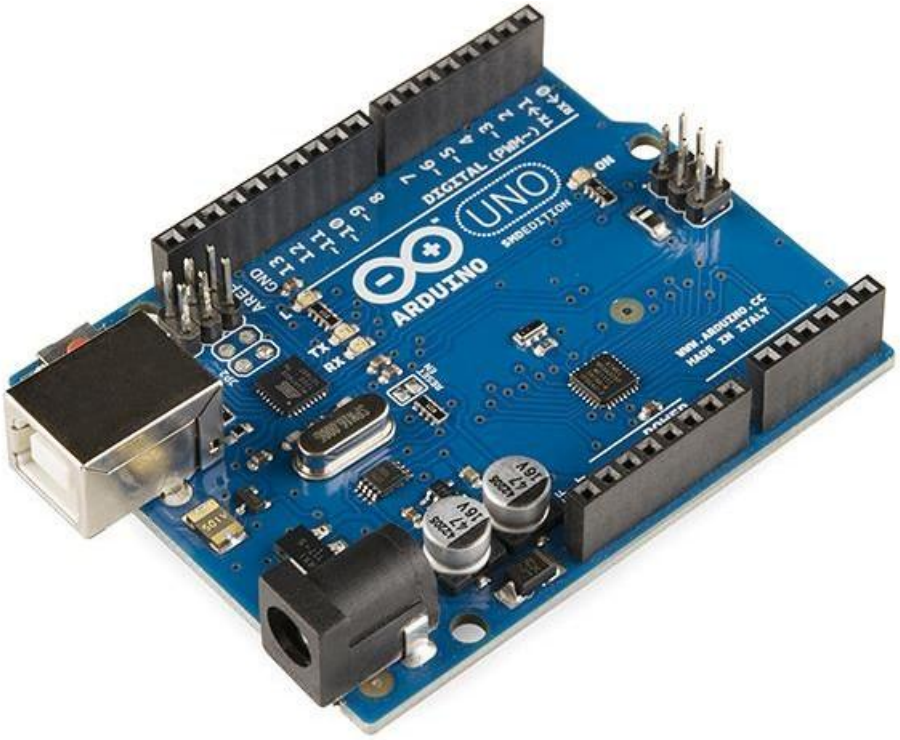

Fig. 3.6 the Arduino

Switches and wires

- Connecting wires about 5mm to stand the load
- Switches for more protection, connected between the load and the inverter's output and between the mppt and the panel to prevent sort circuit.

Fig. 3.7 The switch

Chapter (4)

Procedures and stages

- First of all the panel was installed on a pole about 3 meters tall by 45 degree and in the southeast direction.
- The panel's wires are then connected to the mppt or charge controller but the positive (+) wire with the positive (+) inlet in the mppt, and the same with the negative (-) wire.
- Then the battery is connected with the output of the mppt, also notice that the (+) side of the battery connected with the (+) inlet of the mppt, the same with the (-).
- Now the battery also connected with the inverter considering the (+) and the (-) sides as previous.
- Finally the output of the inverter is connected to the load "it may be the control system or the pumps directly".
- The mppt, battery and inverter are preferred to be as close as the panel to avoid voltage lost.

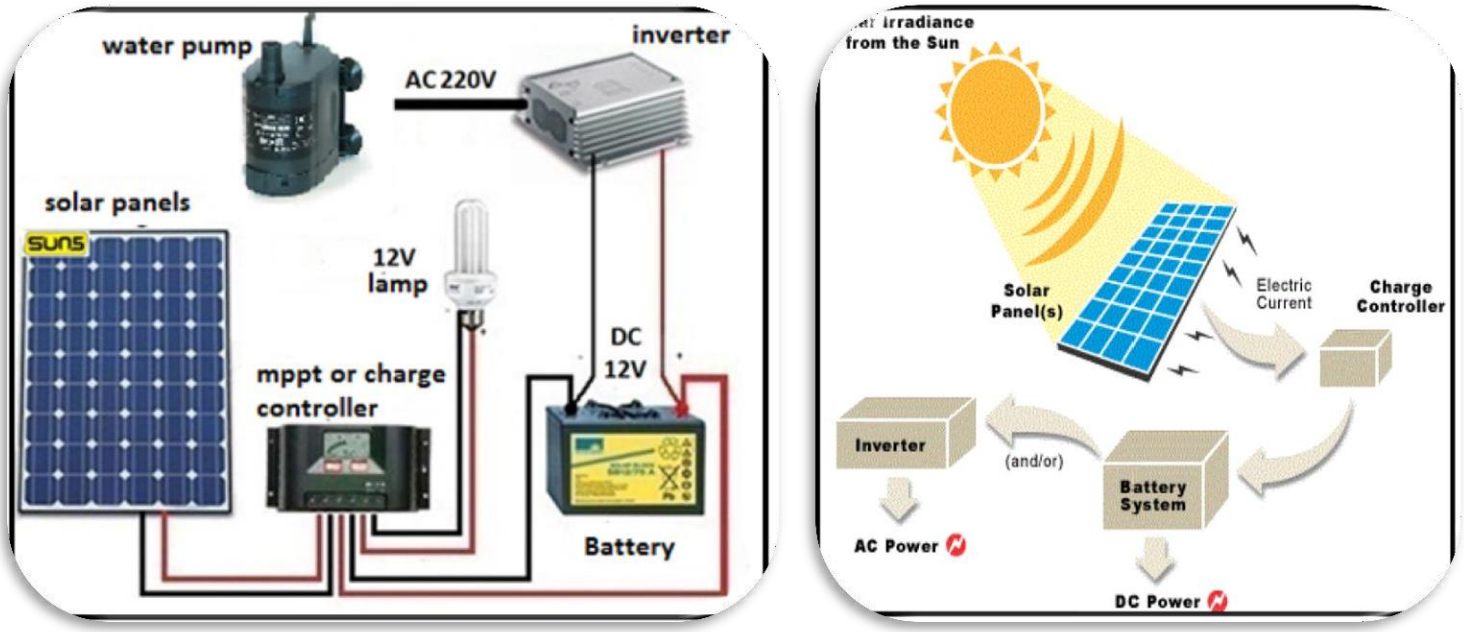

Fig. 4.1 stages of solar system

Fig. 4.2 (a) battery, inverter and switch connected together

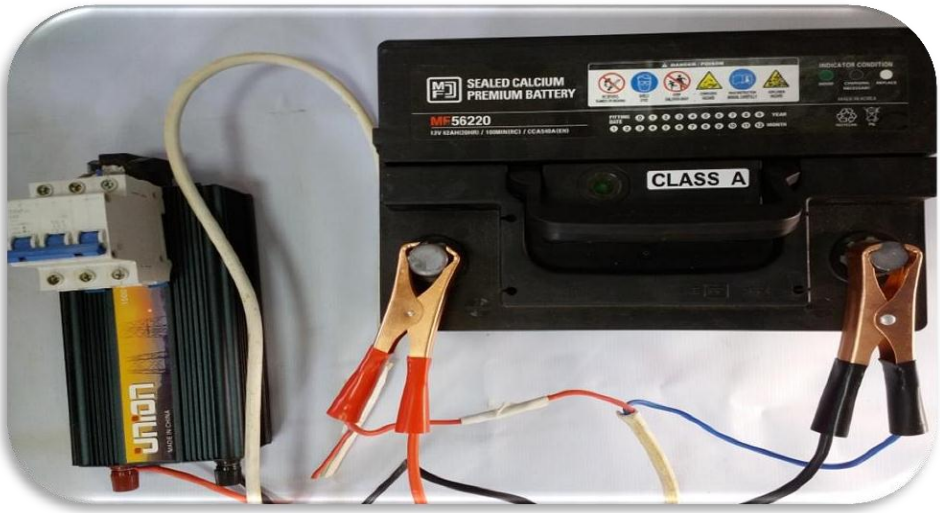

Fig. 4.2 (b) battery, inverter and switch connected together

Fig. 4.2 (c) battery, inverter and switch connected together

Chapter (5)

Results and discussion

Relation (1)

- We have collected some data showing the relation between the DC voltage and the distance.
- The data was taken by a digital avometer shown in fig. 5.2.
- The wire thickness was 5mm.

DC voltage	36.0	35.2	34.6	34.1	33.4	33
Distance (x)	1	1.5	2	2.5	3	3.5

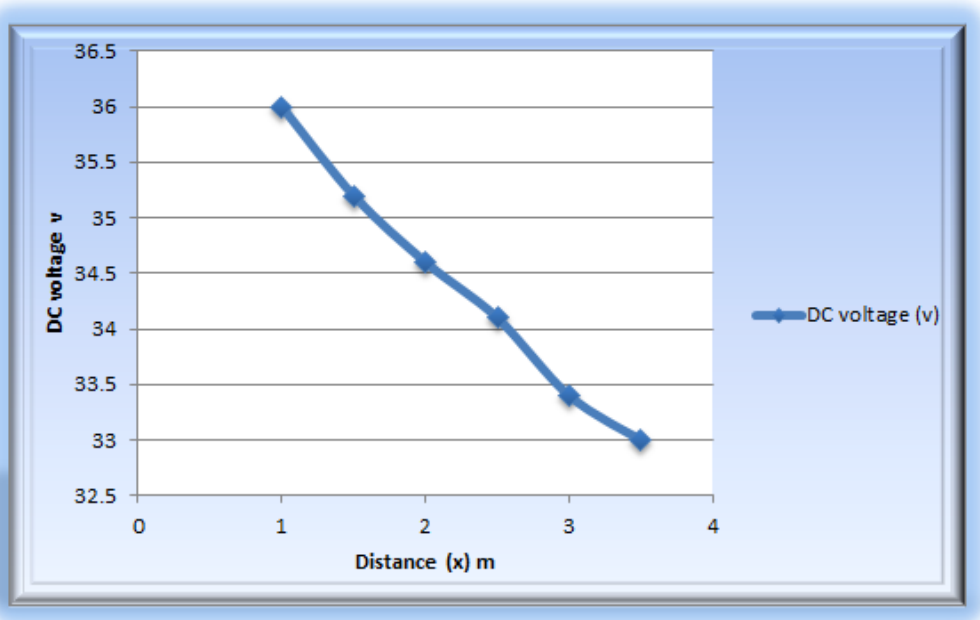

Fig. 5.1 relation between (V) and (X)

- The relation shows that the voltage decreases by distance increase.
- This leads to the fact that the component of the solar system preferred tobe as close as to the panel to avoid voltage also current lost.

Fig. 5.2 the digital avometer

Relation (2)

- In this diagram we show the relation between voltage produces from the panel and number of pumps (load) that our panel could stand.
- As we mentioned the panel voltage at maximum value is 36v DC.

Voltage (v)	36	36	36	24	12	0
No. of pumps (load)	1	2	3	4	5	6

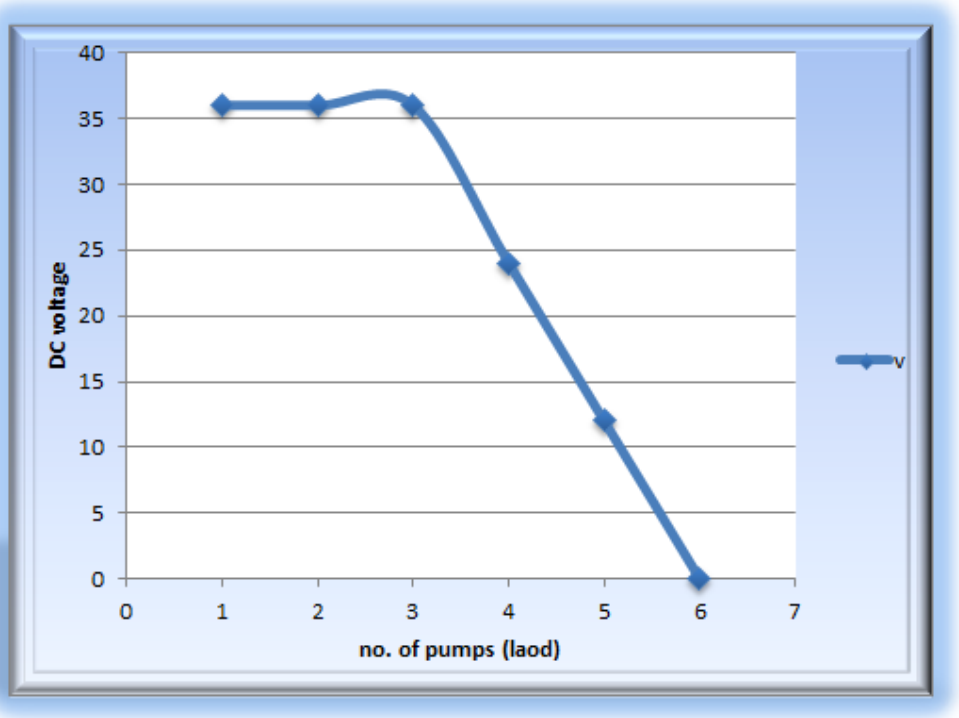

Fig. 5.3 relation between voltage and load

- As we can see the panel keeps a steady voltage of 36v till 3 pumps are connected.
- Any additional load reduces the panel voltage that supply each pump till it becomes zero.
- So to obtain the best performance we should install 3 pumps max.

Summery

- We showed the importance of the hydroponic project and how we can inter the solar system in it.
- We talked about the solar panel structure and the component of solar system.
- Work stages and wiring the component together.
- The obtained results and conclusions

Conclusions from measured data

- "The component of the solar system preferred to be as close as to the panel to avoid voltage also current lost".
- "To obtain the best performance we should install 3 pumps max".

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